AEROCLASS TECHNOLOGIES
YR - 93 Pterodactyl
Final Briefing

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19980309 021

Accession Number: 6329

Title: Aeroclass Technologies, YR-93 Pterodactyl Final Briefing

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Comments on Document: From BMDO/DE, Washington, DC

Abstract: The Pterodactyl Mission is designed to provide localized missile defense by loitering over territory, detecting missile launches, attacking the missile with talons, reposition when required, and provide long endurance coverage.

Descriptors, Keywords: Pterodactylo Yr93 aeroclass technology design concept analysis rationale loiter detection surveillance reconnaissance reposition endurance talon canister mission profile

Pages: 56

Cataloged Date: Jan 06, 1998

Copyrighted or Not: NO

Document Type: HC

Number of Copies In Library: 000001

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INTRODUCTION

I. Problem Statement / Mission Description
II. Design Drivers
III. Concept Description
IV. Alternate Designs
V. Design Analysis and Rationale
VI. Conclusion

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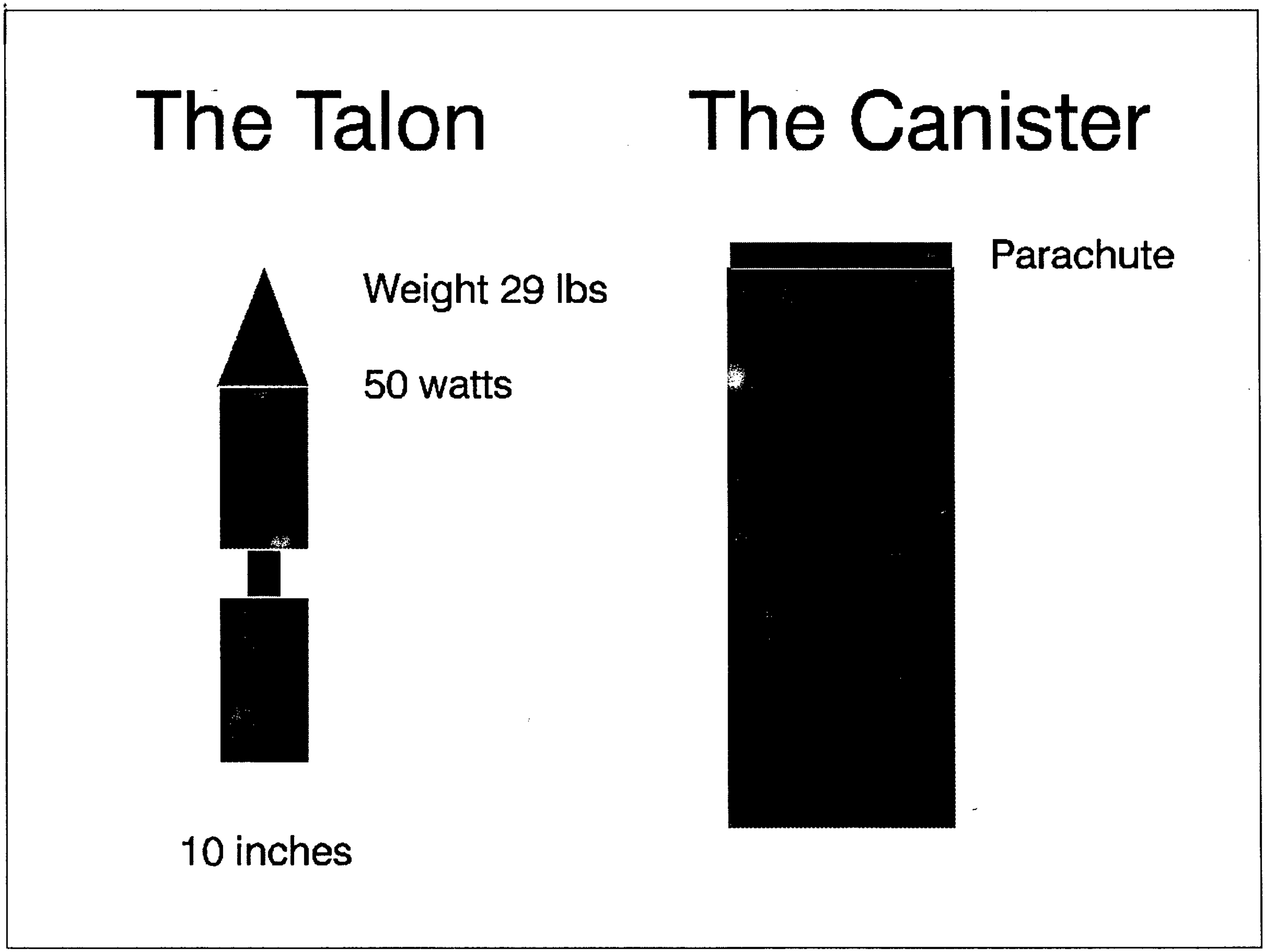
Pterodactyl Mission

Provide Localized Missile Defense

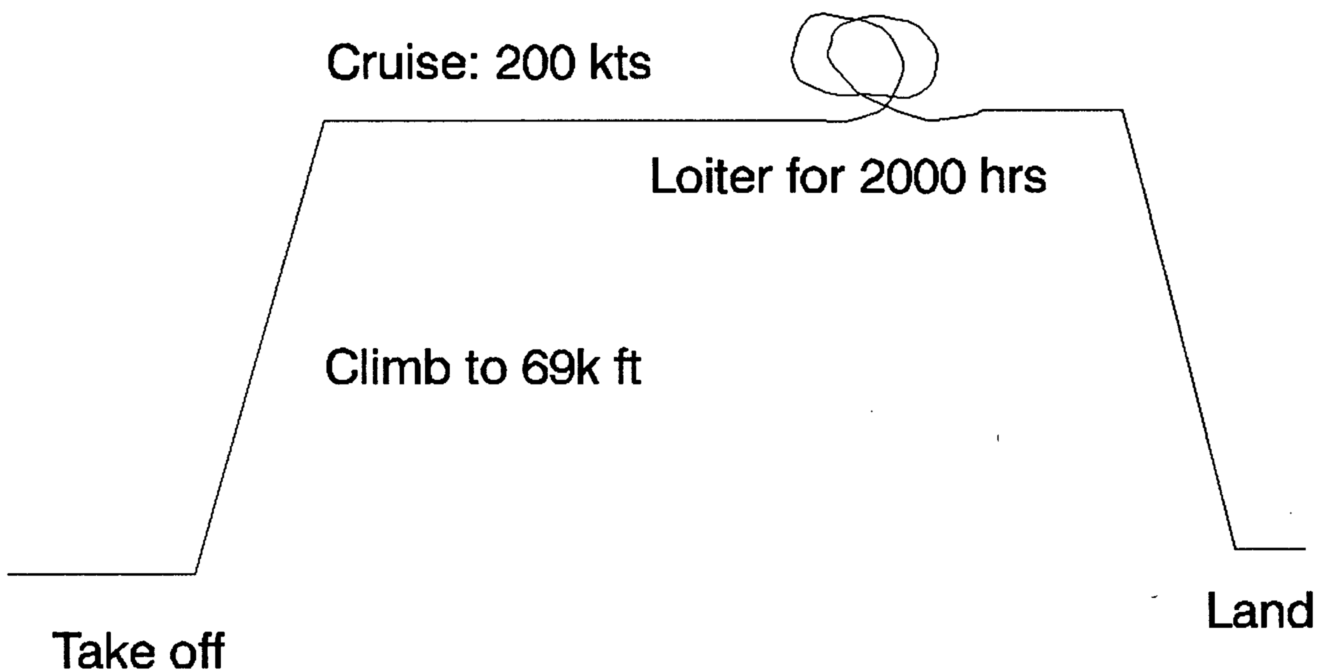
- Loiter Over Territory
- Detect Missile Launch
- Attack Missile with Talons
- Reposition When Required
- Provide Long Endurance Coverage


The Talon
The Canister
Weight 29 lbs
50 watts
Parachute
10 inches

RFP Mission Requirements

√ Mission Endurance	2000 hours
√ Mission Range	4000 miles
√ Payload	200 pounds
√ Max Cruise Speed	200 knots
√ Energy Source	solar/electric
√ Stability	S.M .1 to -.3

RFP Mission Profile



II. Design Drivers

Design Drivers

Most Restrictive Constraints

1. 2,000 Hour Endurance
2. Maximum Altitude of 80,000 feet
    a. Increased Survivability
    b. Increased Potential Energy
3. Highest Cruise Speed as Possible
    a. Try for 200 knots
4. Minimize Power Required
    a. Reduced Fuel Cell Weight
    b. Reduced Cost

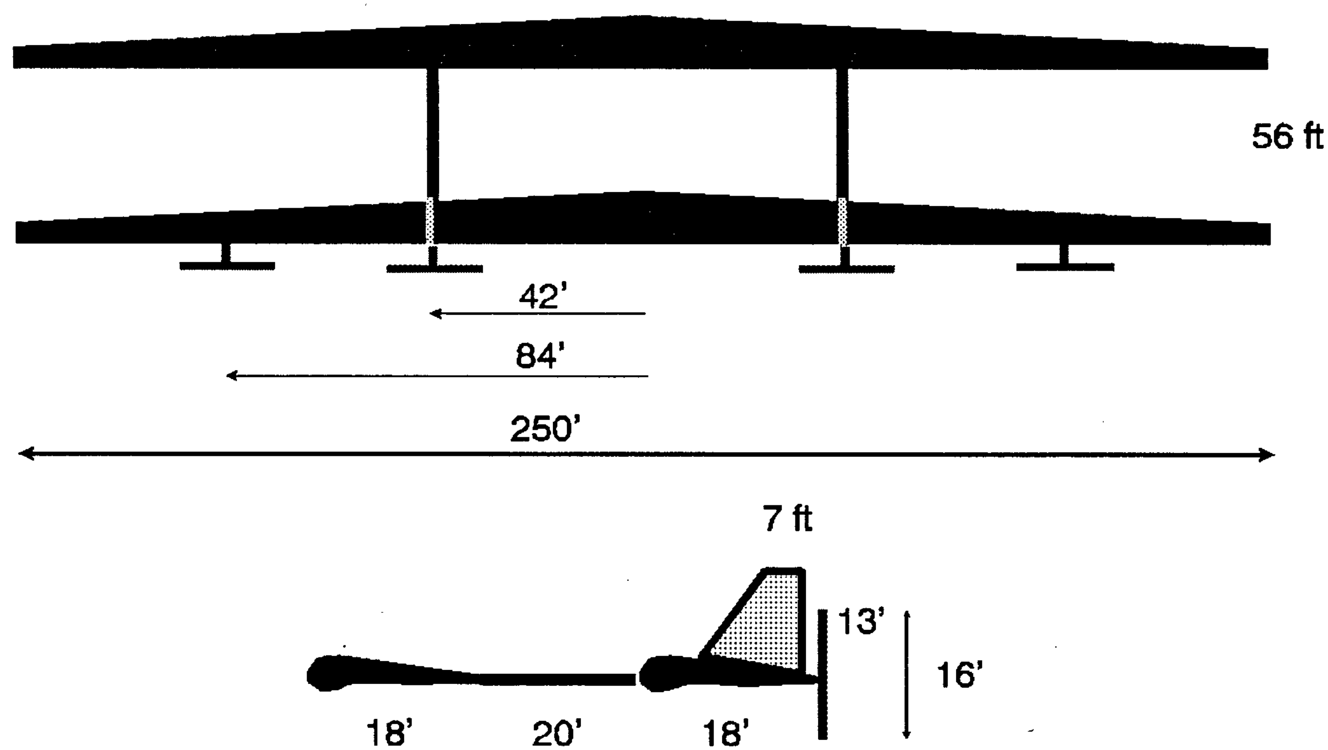
Pterodactyl Concept Description

1. Overall Description
2. Subsystem Description
3. RFP Compliance

1. Overall Description

I. Dimensions
II. Parameters
III. Mission Description
IV. Area Coverage
V. Balsa Wood Glider
VI. Key Mission Elements
VII. Performance
VIII. Constraint Diagram

Pterodactyl Dimensions

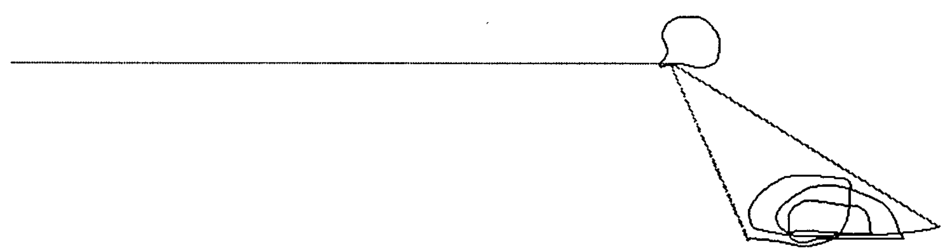


Descriptive Parameters

Planform

Parameter	Wings	Vertical Tails
Span	250 ft	13 ft
Root Chord	18 ft	13 ft
Tip Chord	4.2 ft	7 ft
Area	2775 sq ft each	130 sq ft each
Aspect Ratio	22.5 each	N/A
Sweep	4.7 degrees	26.6 degrees
Airfoil	LDL101b	NACA 0009

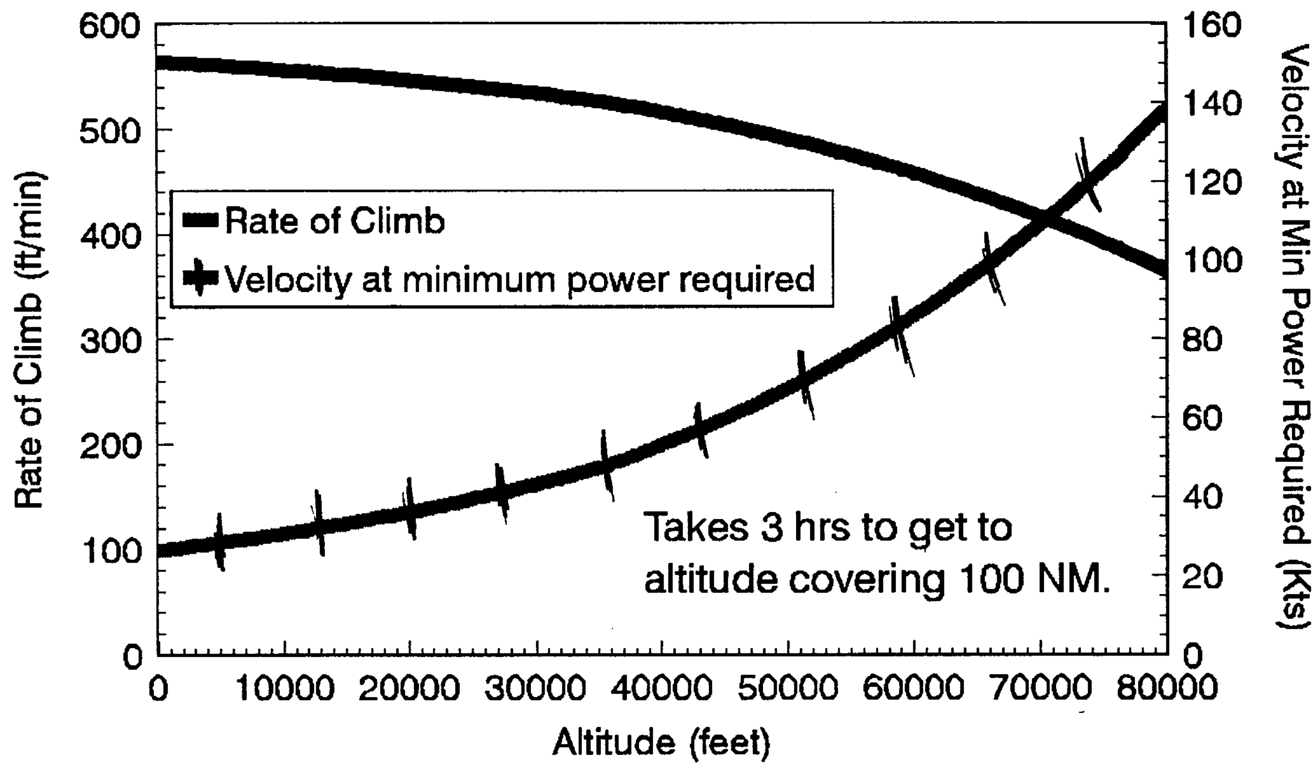
Pterodactyl Mission Profile

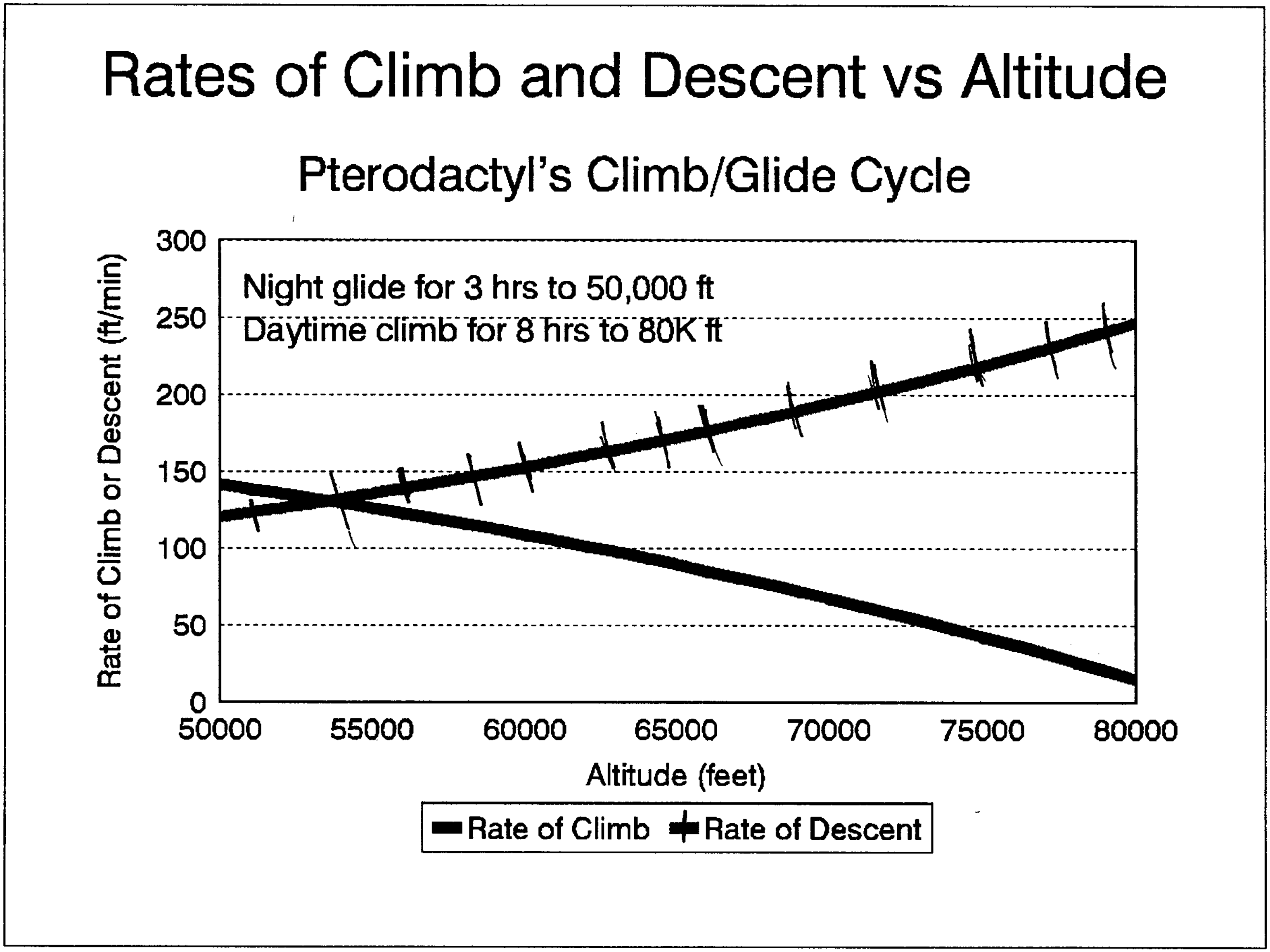


- Initial climb 3 hrs covering 100 NM
- Cruise at 80K ft for 9 hours covering 1300 NM. V = 136 kts
- Night time glide for 3 hours to 50,000 ft.
- Night time loiter at 50K ft for 9 hours. V = 40 kts
- Day time climb for 8 hours.
- Daytime loiter at 80K ft for 4 hours. V = 82 kts.

Pterodactyl's Altitude Profile

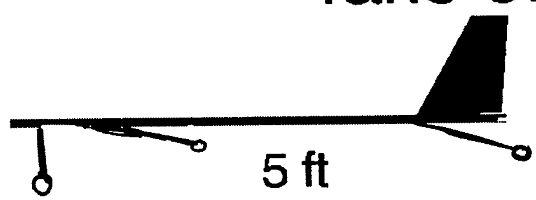
Initial Dash to Target




Rates of Climb and Descent vs Altitude
Pterodactyl's Climb/Glide Cycle
Night glide for 3 hrs to 50,000 ft
Daytime climb for 8 hrs to 80K ft
Rate of Climb or Descent (ft/min)
300
250
200
150
100
50
0
50000
55000
60000
65000
70000
75000
80000
Altitude (feet)
Rate of Climb
Rate of Descent

Key Mission Elements

Take off Configuration



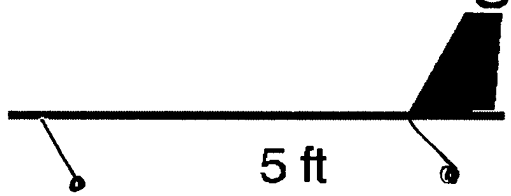
side view

front view

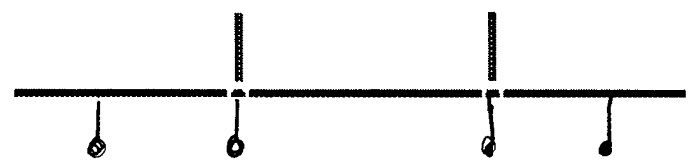
1. Two struts per wing at fuselage intersection.
2. Two struts per wing at outside engine location.
3. All 8 struts release after take off.
4. 8 landing gear struts are retracted during take off.

Key Mission Elements

Landing Configuration



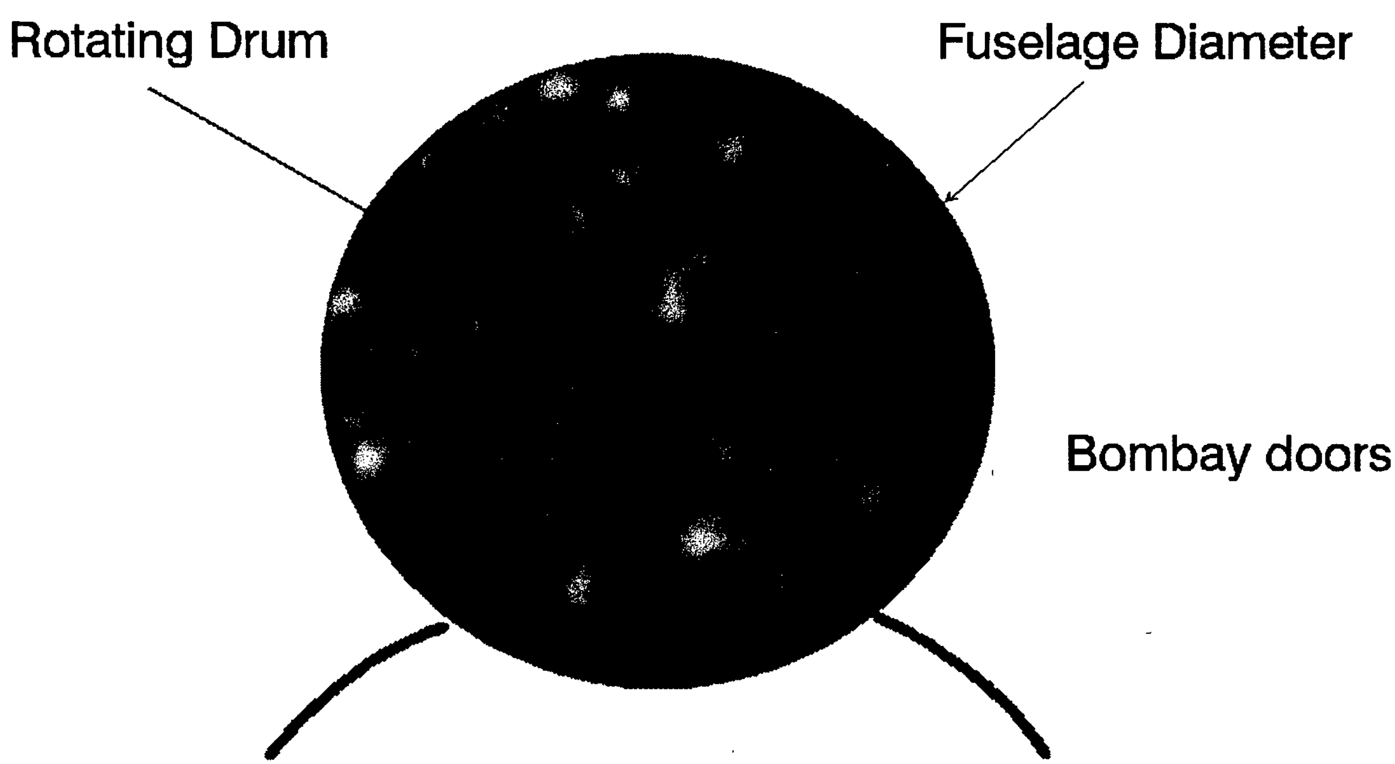
side view



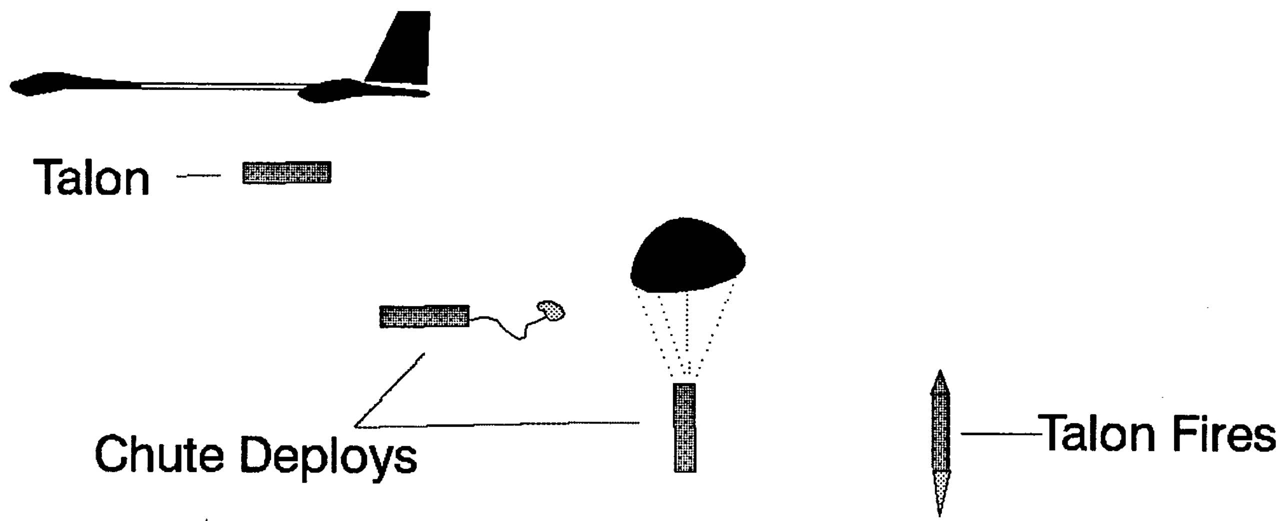
front view

1. 8 landing struts are spring loaded and released before landing.
2. Only good for 1 landing.

Key Mission Elements
Talon Placement



Key Mission Elements
Talon Deployment



Pterodactyl Performance

Parameter	Value
Top Cruise Speed	136 kts
Approach Speed	16 kts
Cl Max	1.6
Max Ceiling	80,000 ft
Sustained Turn	1.1 g
Velocity for Min Pwr Req	40 or 82 kts

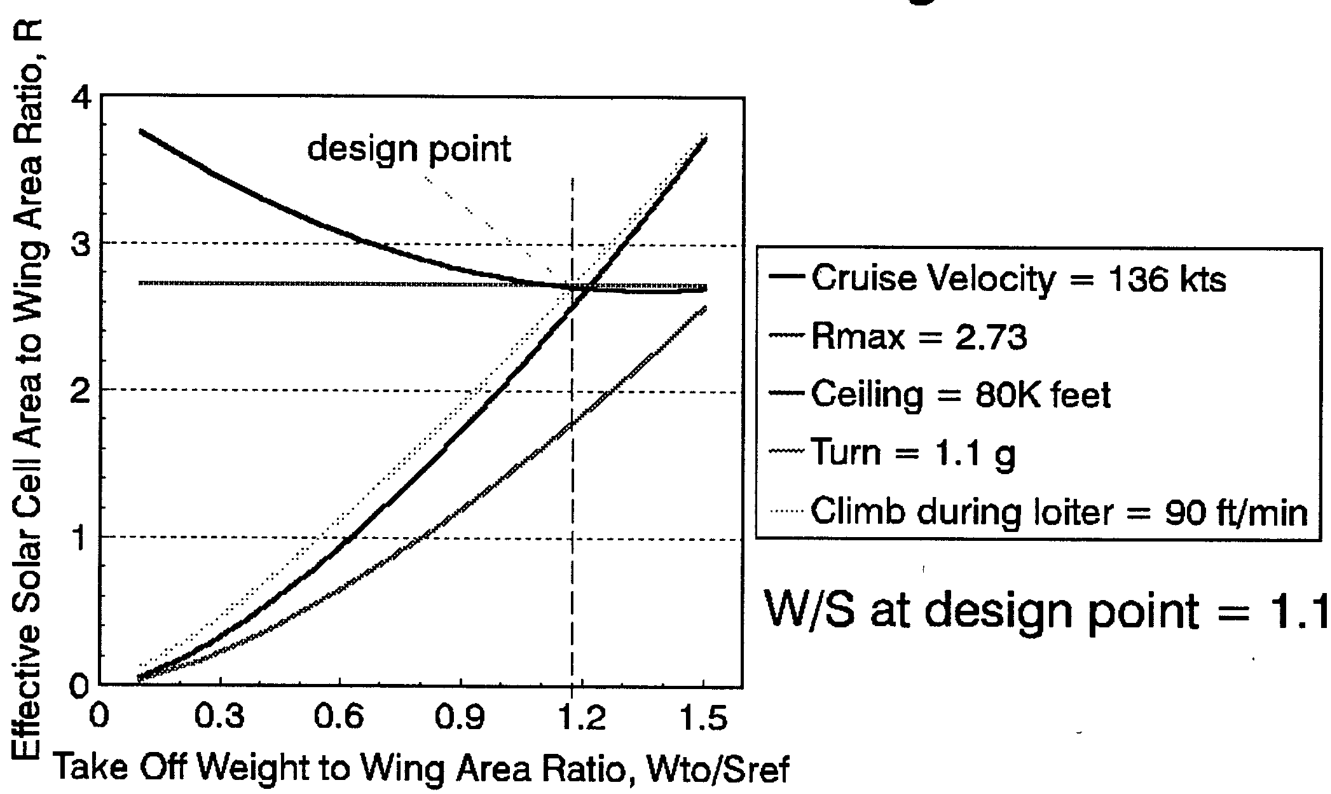
Velocity for Minimum Power Required

for both Loiter Altitudes

1. Night time loiter at 50,000 ft - 40 kts
2. Day time loiter at 80,000 ft - 82 kts

Pterodactyl Constraint Diagram

AEROCLASS Technologies

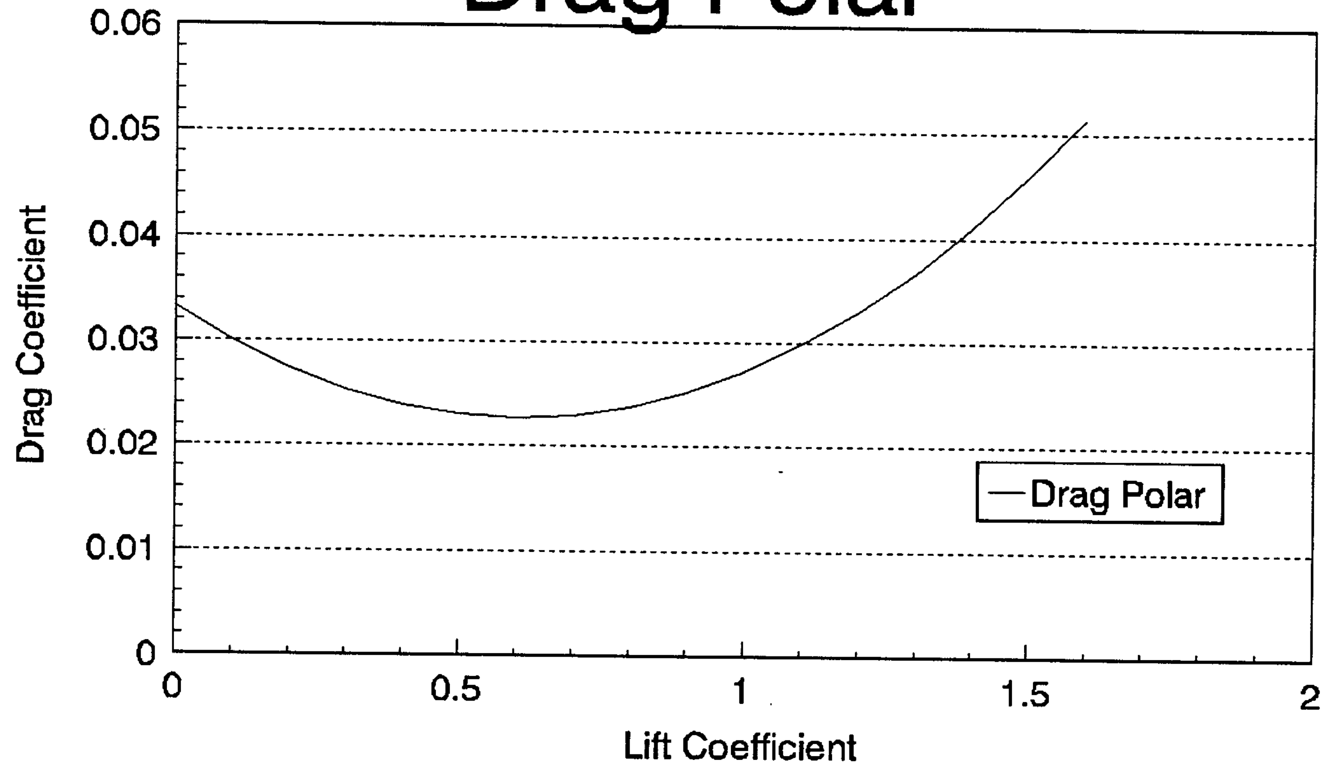


W/S at design point = 1.17

2. Subsystem Description

I. Aerodynamic Description
II. Stability Description
III. Propulsion System Description
IV. Structures Description
V. Weights and CG
[redacted]

Aerodynamic Description
Drag Polar



$$C_D = 0.03325 + 0.029C_L^2 - 0.035C_L$$

Stability Description

Stability Derivative Summary

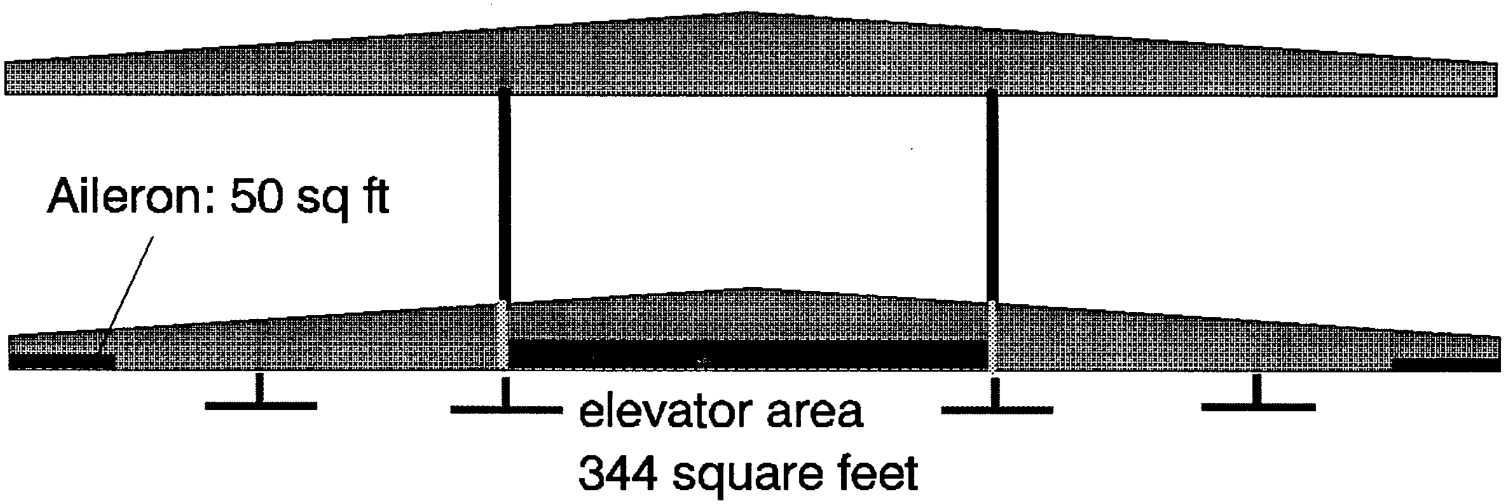
Stability Derivative	Natural Value	Required Value	Using SAS
Longitudinal			
Cm_{α}	0.014	from -0.5 to -0.1	-0.3
Cm_q	-5.15	within range	not needed
Lat-Directional			
Clp	-1.2	slightly high	not needed
Cl_{β}	-0.06	within range	not needed
Cn_{β}	0.001	within range	not needed
Cnr	-0.2	within range	not needed

Stability Description

Results on Modes

Mode	Natural Frequency	Damping Ratio	Meet Mil-Spec
Short Period	0.01	1.21	no
-- with SAS	0.042	0.29	yes
Phugoid	0.34	0.32	yes
Spiral	Time to 2X amp	= 414 sec	yes
Dutch Roll	0.009	2.59	yes

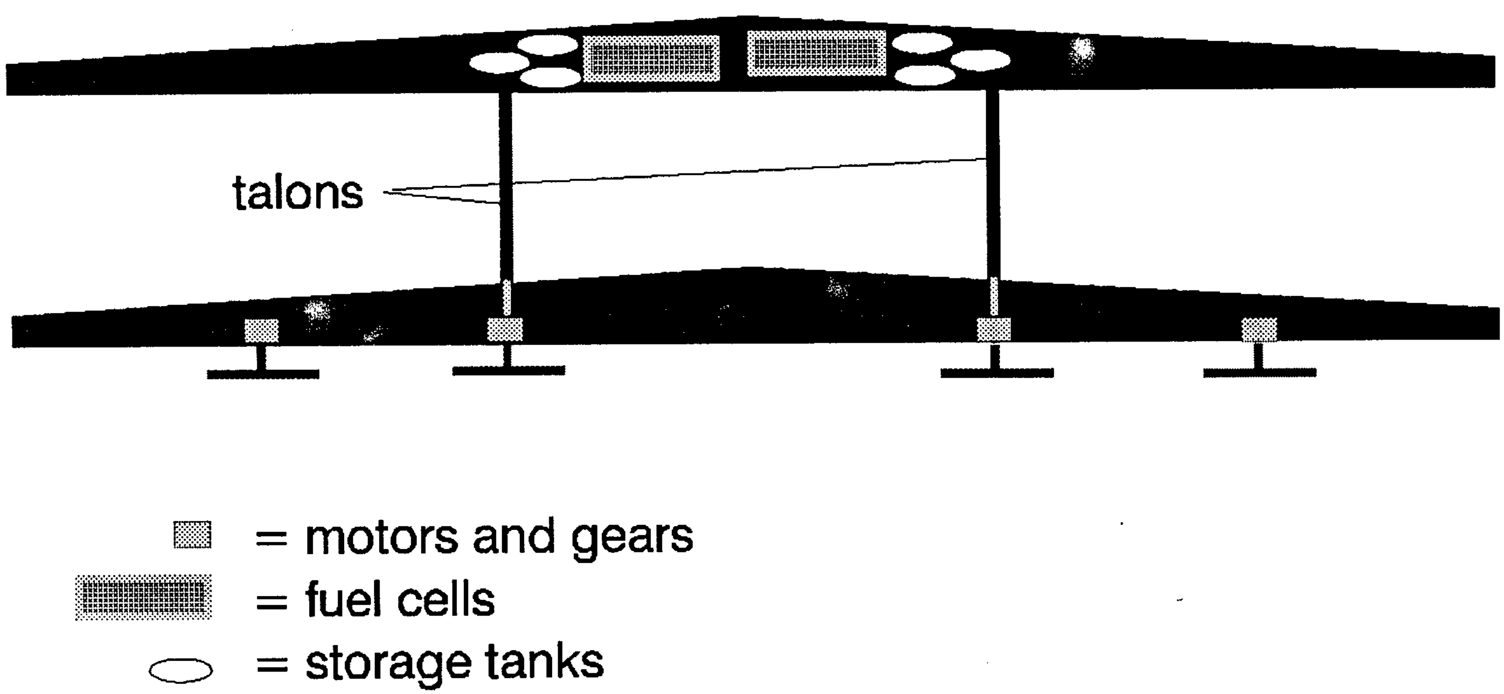
Stability Description
Control Placement



Trimmed flight :

0 degrees AOA: deflection equals -2.5 degrees
6 degrees AOA: deflection equals 2.5 degrees

Stability Description Systems Placement

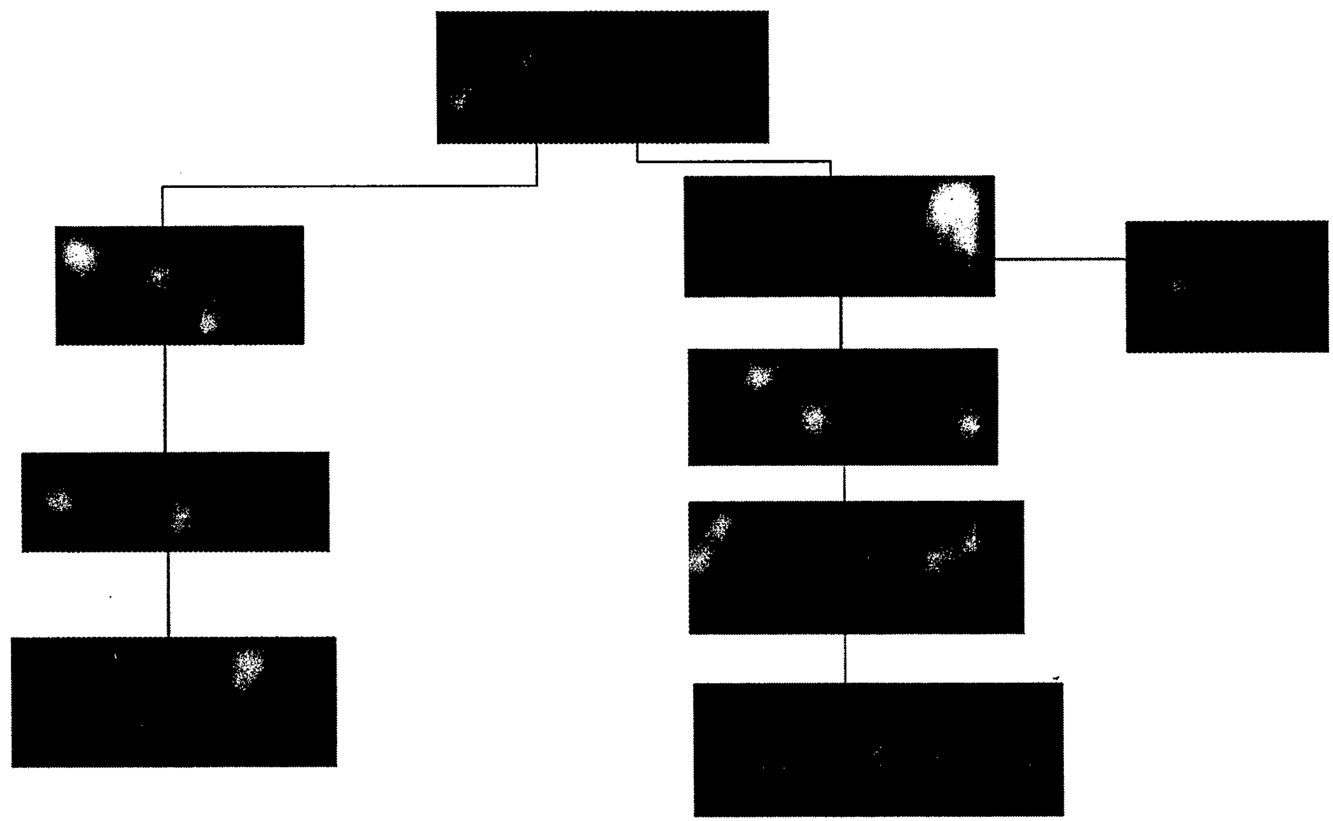


Propulsion System Description

System Summary

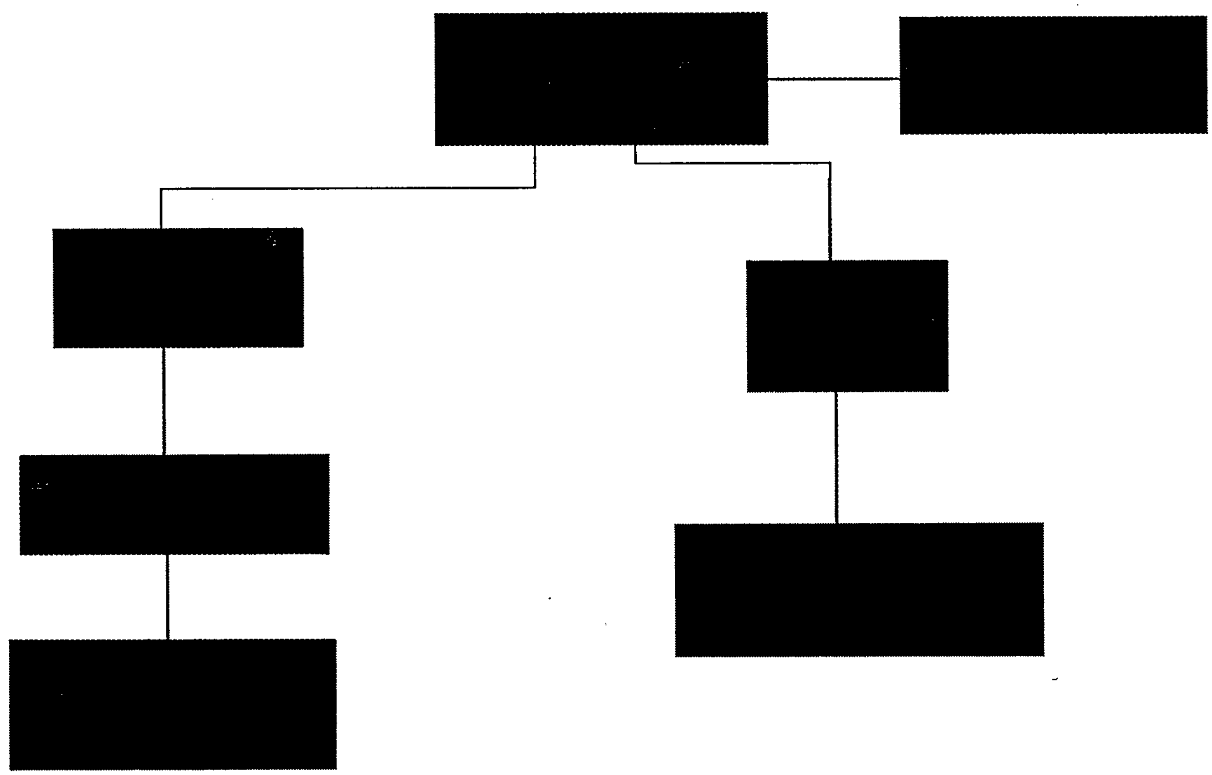
1. Power Source
   a. Solar Cells
      i. CIS-Se (c)ii
      ii. Effective Area = 7576 sq ft
      iii. Actual Area = 11,587 sq feet
   b. Fuel Cells
      i. 4.0 KW H_2O_2
2. Motors
   a. 4 General Electric 6.0 horsepower motors
   b. 1900 RPM
3. Propellors
   a. 4, 16 foot diameter propellers
   b. 475 RPM (400 ft/sec tip speed)
4. Gear box with gear ratio of 4:1

Propulsion Description
Day Operation



Propulsion Description

Night Operation



Propulsion Description

Final System Efficiencies

Component	Efficiency	Energy Density
Solar Cells	15%	2000 Watts/kg
Fuel Cells	53%	352 W-hrs/kg
Motor	90%	N/A
Gear	95%	N/A
Propeller	86%	N/A
Cf	0.374	N/A

Structures Description

Composition

I. Wings
   A. Skin
      1. MYLAR skin
      2. solar cells
      3. TEDLAR covering
   B. Ribs
      1. graphite/epoxy composite shell
      2. foam core
   C. Tubular Spar
      1. +-45 degree graphite/epoxy thin tube

II. Fuselage and Vertical Tails
   A. Standard airframe structures

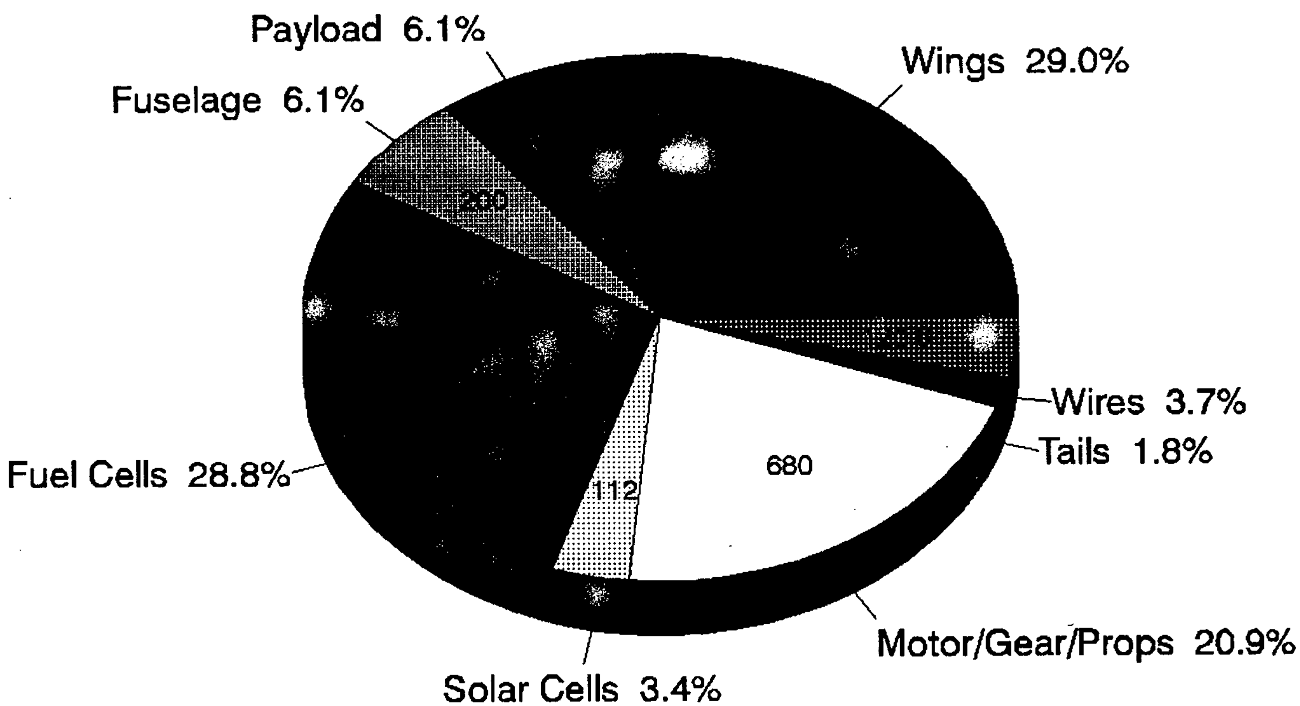
Structures Description

Finite Element Results

- Actual Results
  - Top skin fails in compression
  - Wing tip deflection = 22 feet
  - Safety factor of 3.5
- Realistic Analysis
  - Top skin is flexible in compression
  - Span loading was not taken into account

Pterodactyl Final Weight Breakdown

Total Weight = 3255 lbs



RFP Compliance Table

Pterodactyl Performance Report

Parameter	Required	Pterodactyl
Max Cruise Speed	200 kts	136 kts
Mission Endurance	2000 hrs	infinite
Mission Range	4000 NM	infinite
Payload	200 pounds	200 pounds
Absolute Ceiling	70,000 ft	80,000 ft
Power Source	Solar	Solar and Fuel Cells
Static Margin	.1 to -.3	-0.02

IV. Alternate Designs

Peregrine

I. Reference Area = 3600 sq ft

II. Wing/Canard Configuration

    a. Wing Area = 3600 sq ft

    b. Canard Area = 1800 sq ft

    c. Canard 10 ft above wing

III. 2 propellers with 2 motors per propeller

IV. No vertical stabilizers

Alternative Designs

Night Owl

- Reference Area = 2550 sq ft
- Wing and Canard Configuration
  - Wing Area = 2550 sq ft
  - Canard Area = 400 sq ft
- Two 15 Foot Diameter Propellers
- One Motor per Propeller
- No Vertical Stabilizers

V. Configuration and Design Justification

1. Aerodynamic Analysis
2. Stability and Control
3. Propulsion
4. Weight Breakdown
5. RFP Compliance

1. Aerodynamic Analysis

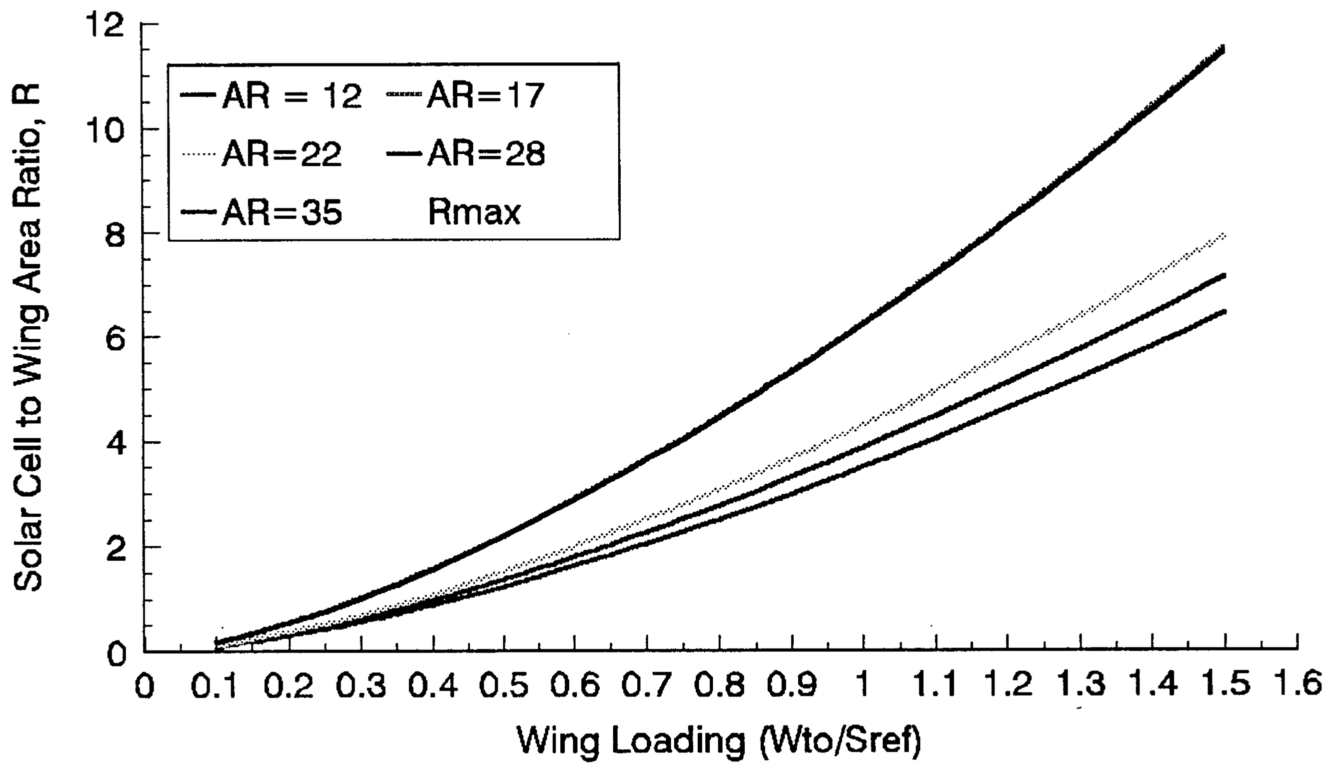
a. Aspect Ratio Comparisons

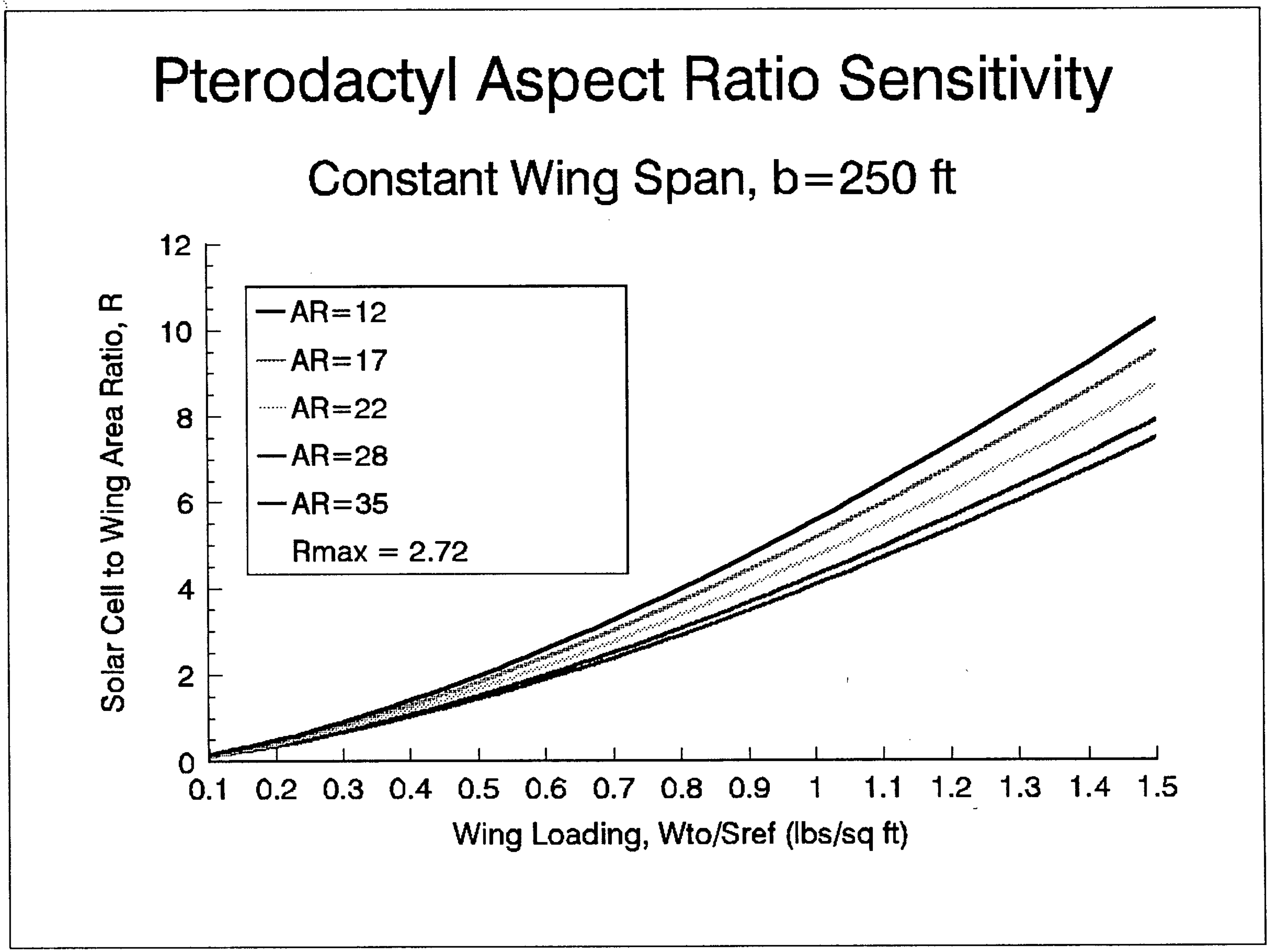
b. Zero lift Drag

c. Power Required vs Velocity

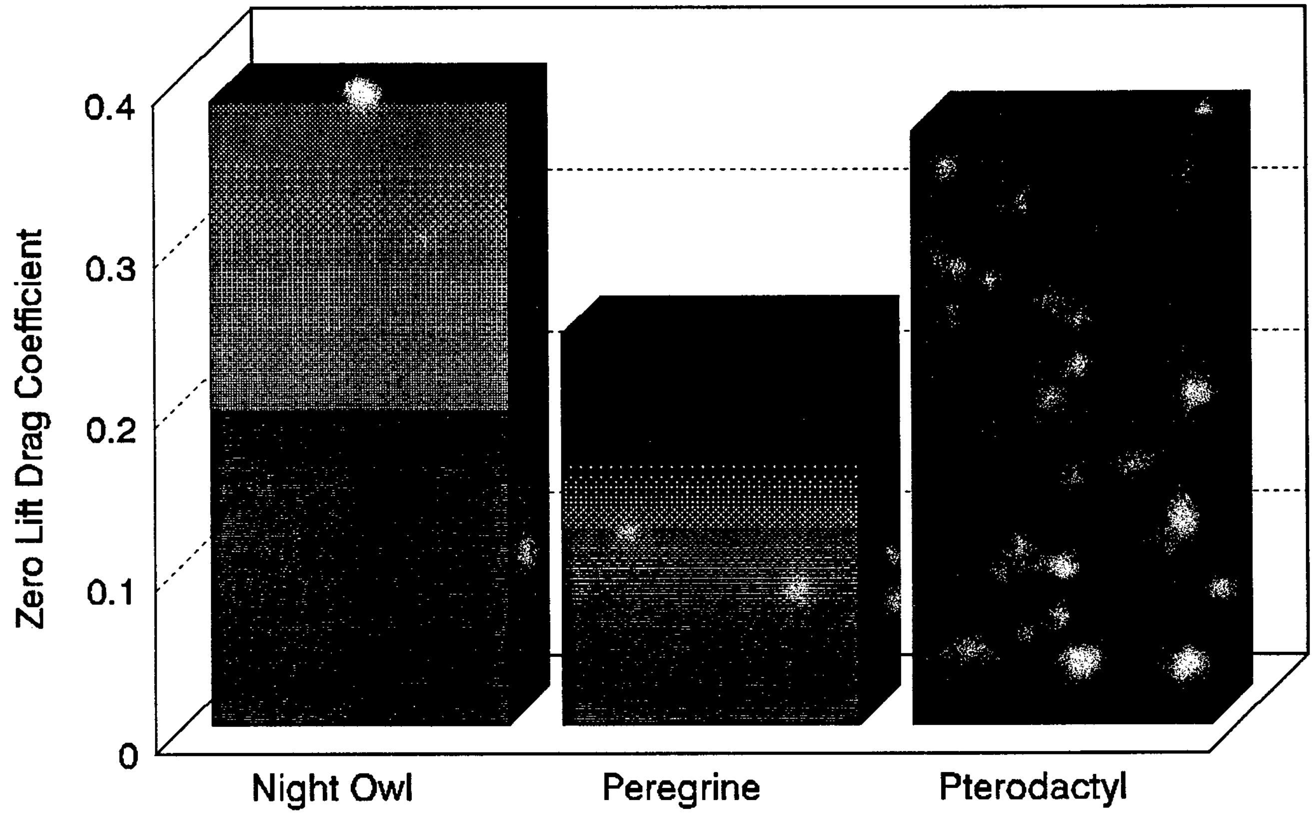
Pterodactyl Aspect Ratio Sensitivity

Constant Wing Area, S=2775 sq ft



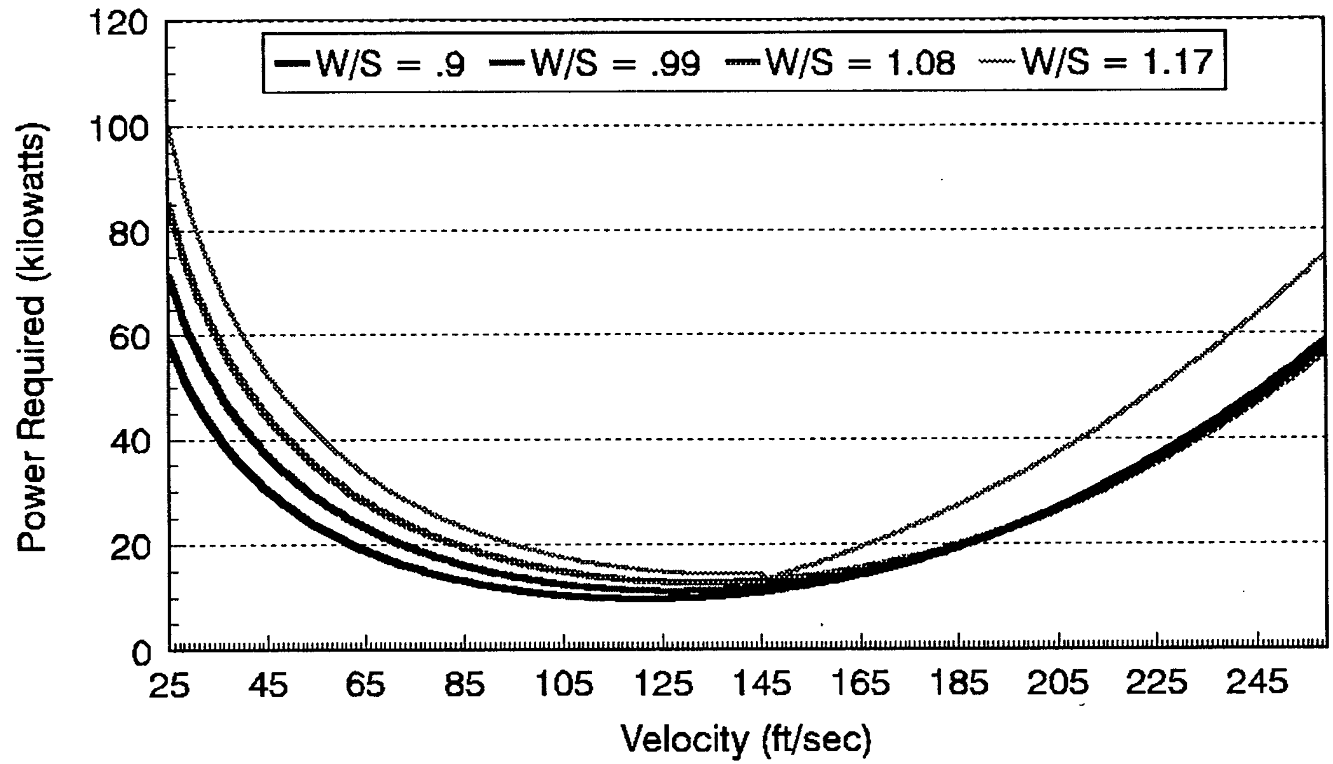

Pterodactyl Aspect Ratio Sensitivity
Constant Wing Span, b=250 ft
AR=12
AR=17
AR=22
AR=28
AR=35
Rmax = 2.72
Solar Cell to Wing Area Ratio, R
Wing Loading, Wto/Sref (lbs/sq ft)
0
2
4
6
8
10
12
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5

Wing and Canard Zero Lift Drag Comparing All Three Aircraft



Power Required vs Velocity

Pterodactyl at 80,000 feet



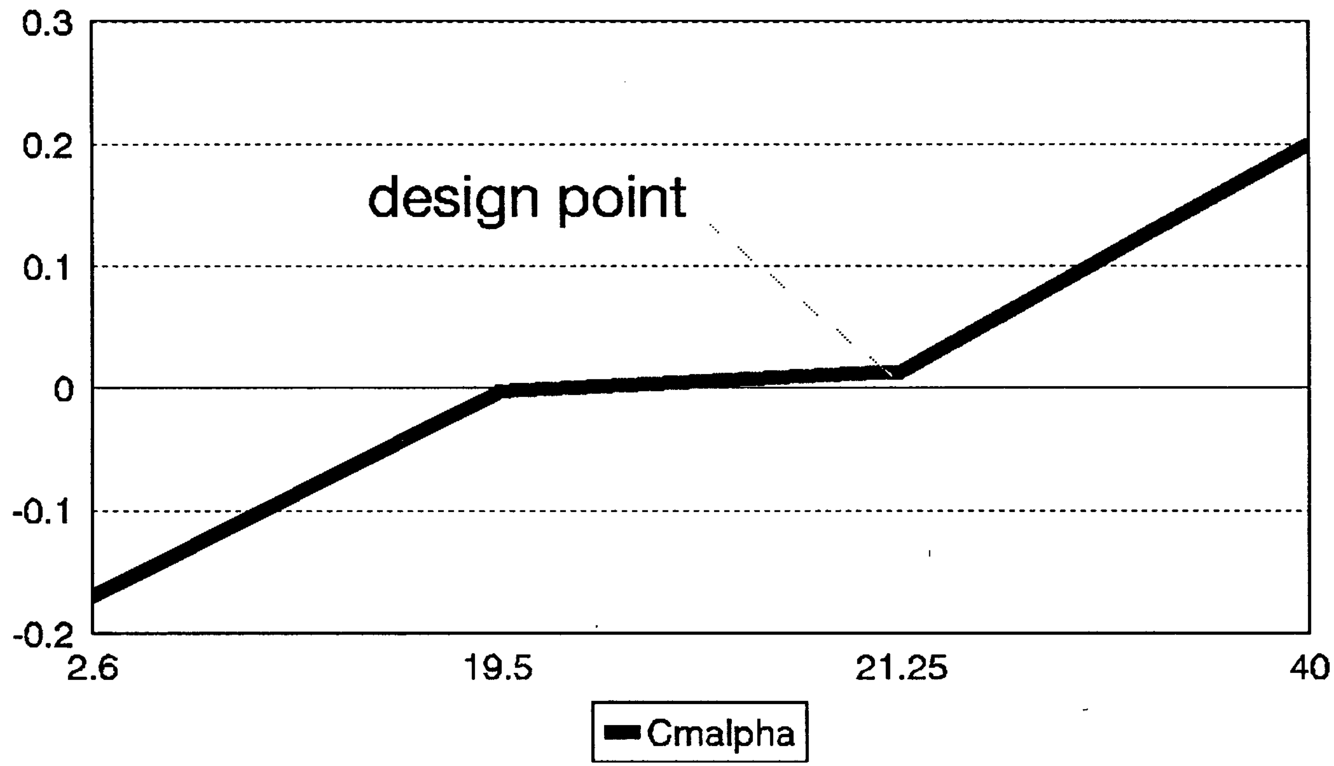
2. Stability Analysis

a. Longitudinal Sensitivity

b. Lateral-Directional Sensitivity

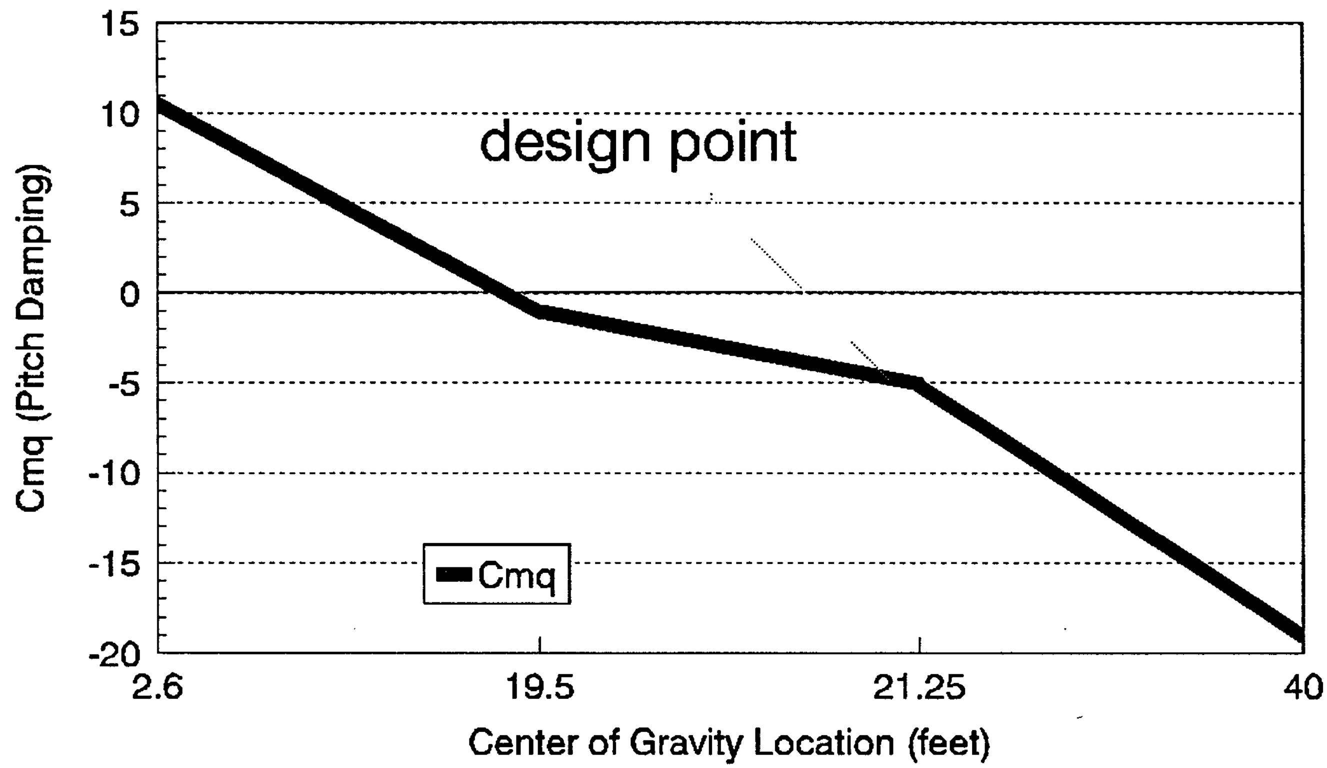
Stability Analysis

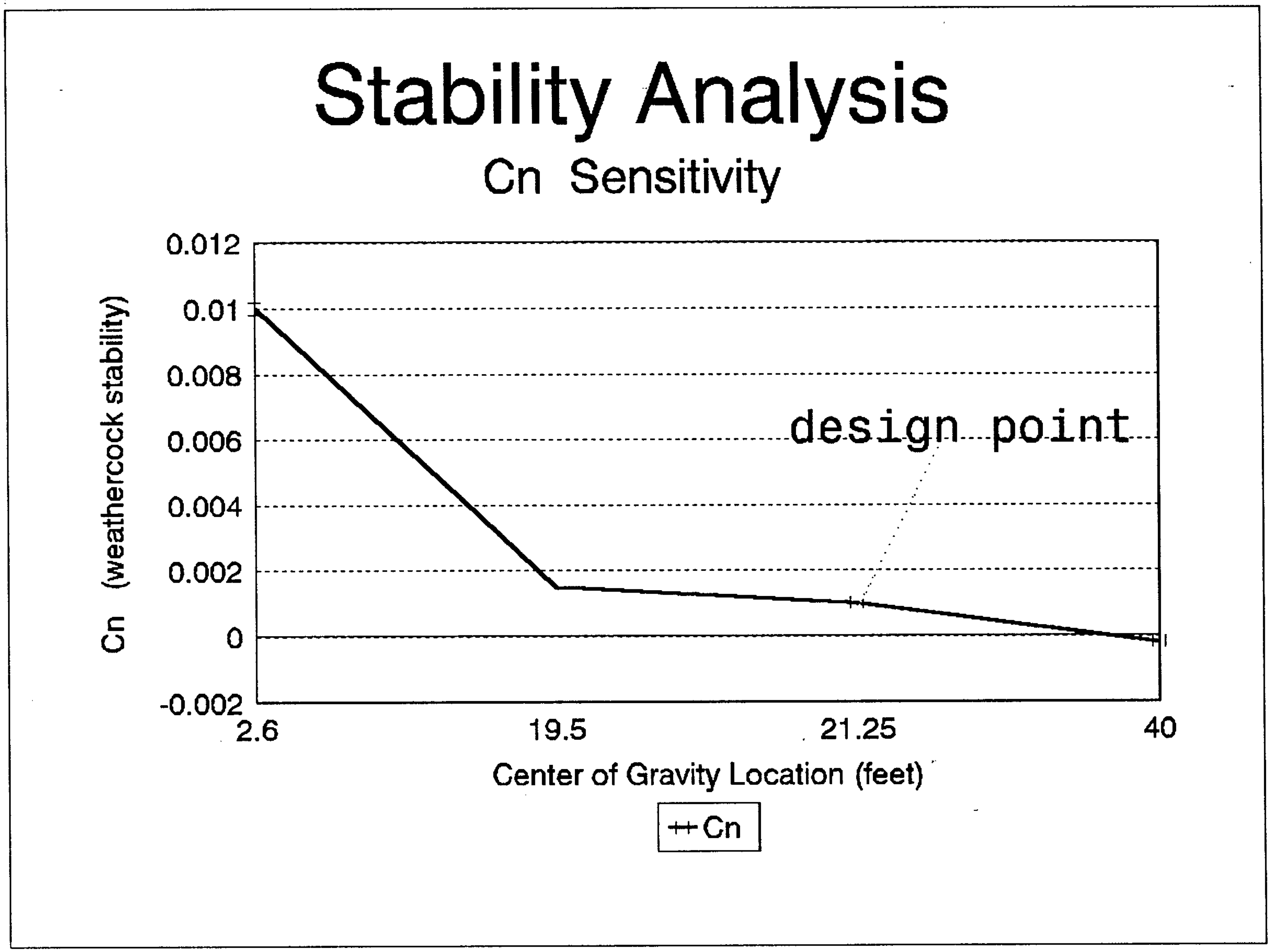
Cm_{α} Sensitivity

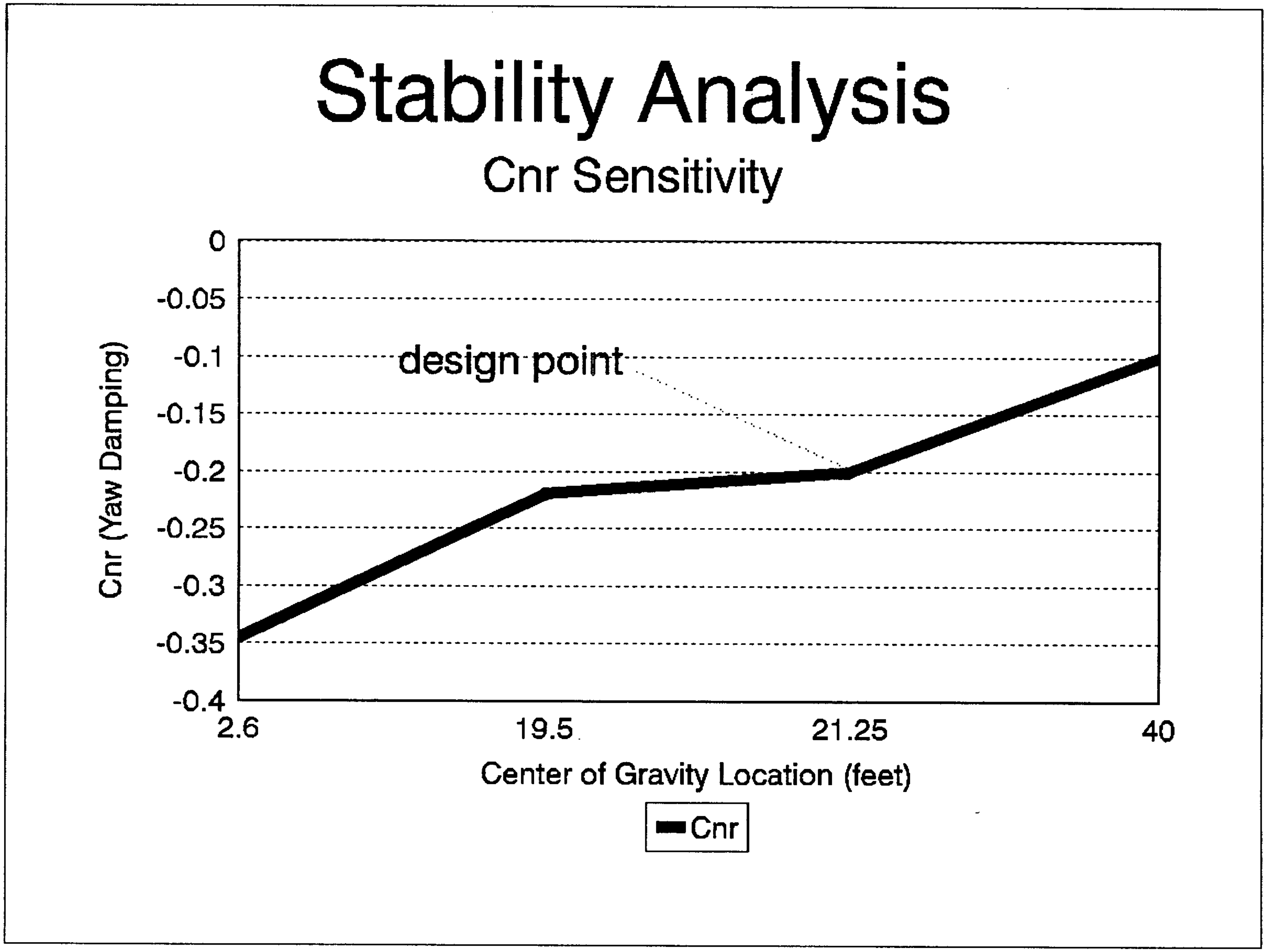


Stability Analysis

Cm_q Sensitivity




Stability Analysis
Cn Sensitivity
0.012
0.01
0.008
0.006
0.004
0.002
0
-0.002
Cn (weathercock stability)
design point
2.6
19.5
21.25
40
Center of Gravity Location (feet)
Cn



Stability Analysis
Cnr Sensitivity
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
-0.35
-0.4
Cnr (Yaw Damping)
design point
2.6
19.5
21.25
40
Center of Gravity Location (feet)
Cnr

FLIGHT SIMULATOR TIME

3. Propulsion Analysis

a Fuel Cell and Battery Comparisons

b. Solar Cells Considered

c. Solar Cell Comparison

Propulsion Analysis

Fuel Cell / Battery Comparisons

CELL	Specific Energy (W - hrs/kg)	Technological Maturity	WEIGHT
NiCd	30	Mature	7195.887
Lead Acid	35	Mature	6167.903
NiMH	54	Experimental	3997.715
Zn/AgO	90	Mature	2398.629
NaS	100	Mature	2158.766
Li/LiCo2	132	Experimental	1635.429
Li-FeS2	180	Experimental	1199.314
Li- Solid Polymer	160	Experimental	1349.229
H2 O2 Fuel Cell	142.5	Mature	1514.923
H2 O2 Fuel Cell	**352**	**Developing**	**596.3442**

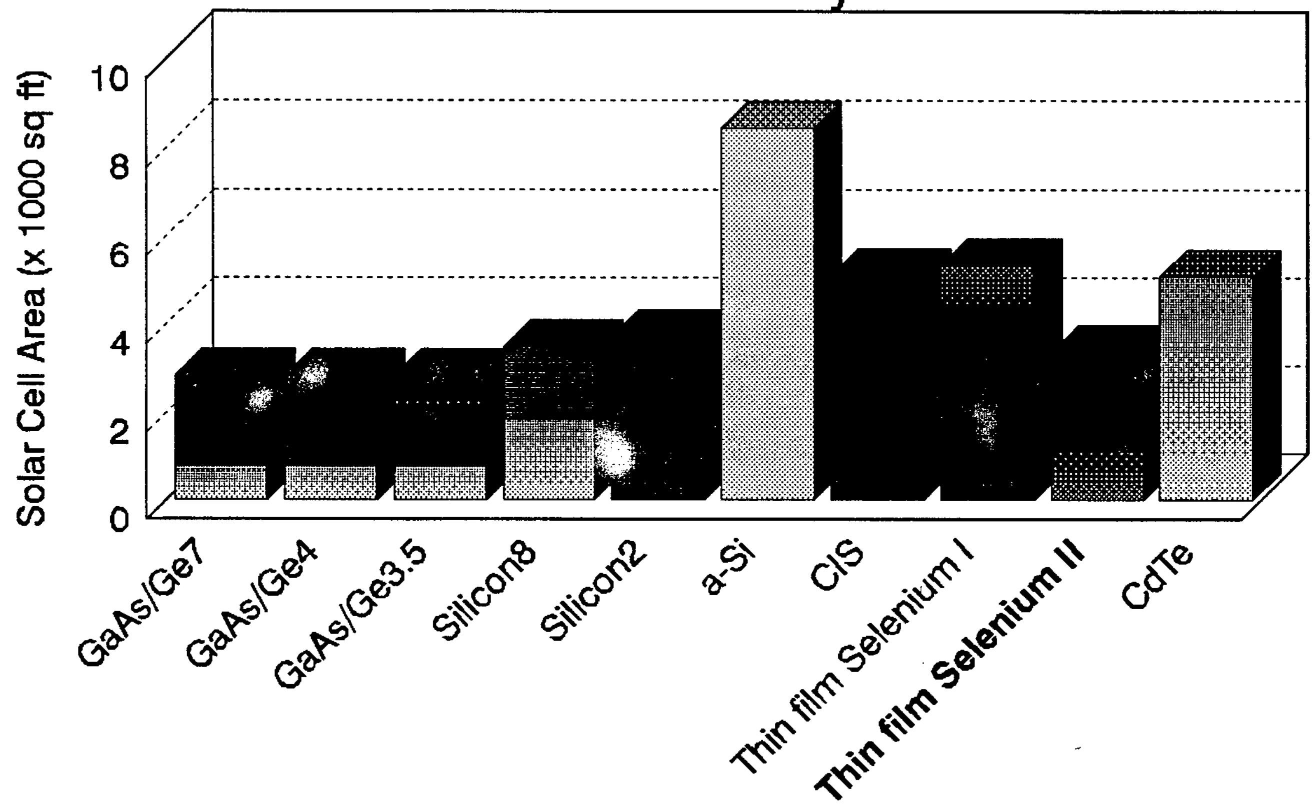
Propulsion Analysis

Solar Cells Considered

	Solar Cell	Efficiency
1	GaAs/Ge7	0.180
2	GaAs/Ge4	0.180
3	GaAs/Ge3.5	0.180
4	Silicon8	0.145
5	Silicon2	0.137
6	a-Si	0.060
7	CIS	0.099
8	Thin film Selenium I	0.095
9	**Thin film Selenium II**	**0.150**
10	CdTe	0.100
Future Cell (req. to go 200kts)		0.54

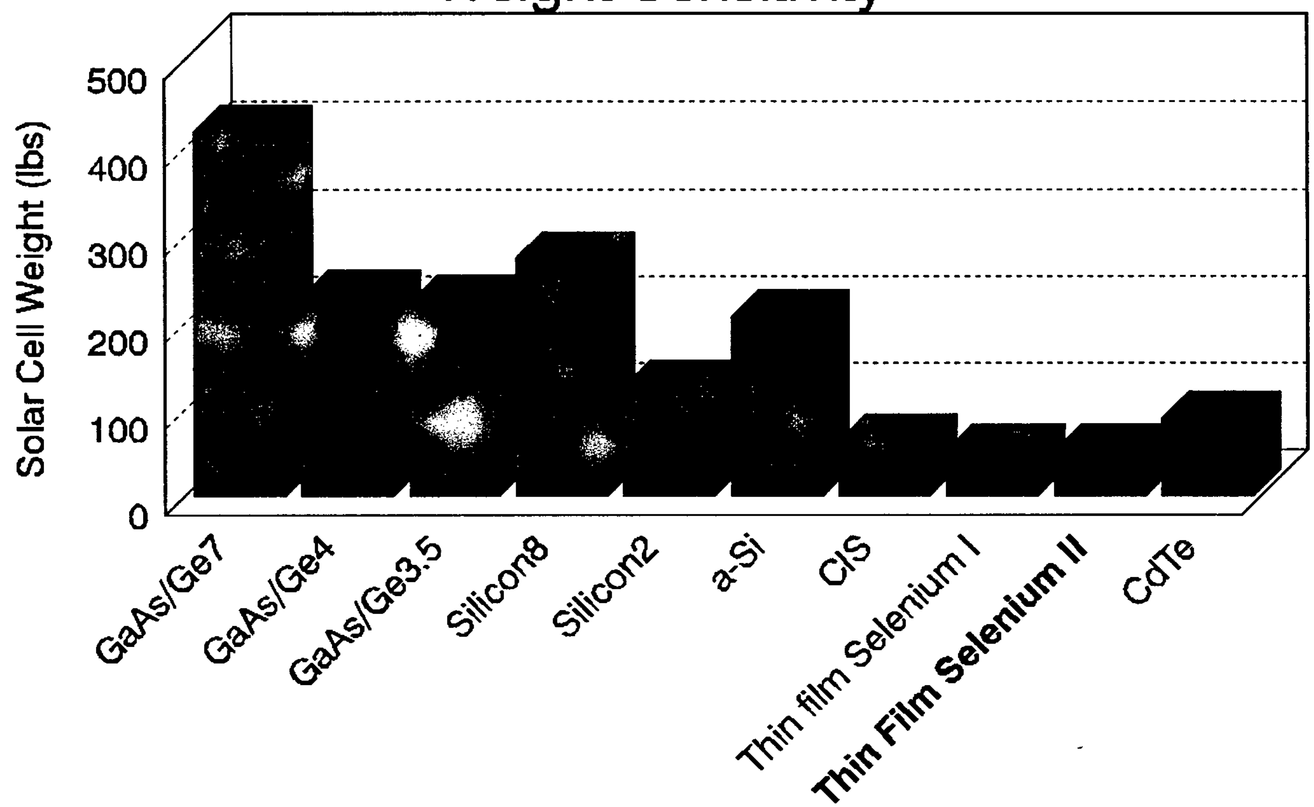
Propulsion Analysis

Area Sensitivity



Propulsion Analysis

Weight Sensitivity



CONCLUSION

- Meets all RFP Requirements Except:
  - →Max Cruise Speed
- Propulsion
  - →Uses Solar Power and Fuel Cells
  - →Uses 3 hours of night time glide to decrease fuel cell weight
- Solar Cell Cost is Much too High to even Consider Use